REMARKS/ARGUMENTS

Favorable reconsideration of this application for the reasons noted hereinafter is respectfully requested.

Claims 1-4, 17 and 21-24 are active in this case, Claims 5-16 and 18-20 having previously been withdrawn.

In the outstanding Office Action, Claims 1 and 21-24 were rejected under 35 U.S.C. § 103(a) as unpatentable over Sportouch et al. (Thermoelectric Properties of Half-Heusler Phases: $ErNi_{1-x}Cu_xSb$, $YNi_{1-x}Cu_xSb$ and $Zr_xHf_yTi_zNiSn$, 18th International Conference on Thermoelectrics, 1999, pgs 344-347; hereinafter "Sportouch") in view of Shen et al. (Synthesis and Sintering of ZrNiSn Thermoelectric Compounds, 21st International Conference on Thermoelectrics, August 25-29, 2002, pgs 166-169, hereinafter "Shen"); Claims 2-4 were rejected under 35 U.S.C. § 103(a) as unpatentable over Sportouch in view of Shen, further in view of Hohl et al. (Efficient dopants for ZrNiSn based thermoelectric materials, J. Phys.: Condens. Matter, 11, 1999, pgs 1697-1709; hereinafter "Hohl"); and Claim 17 was rejected under 35 U.S.C. § 103(a) as unpatentable over Sportouch in view of Shen, further in view of Bell (U.S. Patent No. 6,700,052).

In response to the rejections under 35 U.S.C. § 103(a), Applicants respectfully request reconsideration of the rejections and traverse the rejections as discussed next.

Independent Claim 1 is directed to a:

> ...thermoelectric material which is a sintered body and represented by composition formula (1) and comprises as a major phase an MgAgAs crystal structure, ***the sintered body being obtained by melting raw materials to obtain melted raw materials, quenching the melted raw materials to obtain an alloy formed of a metallic lump***, pulverizing the alloy to obtain an alloy powder, and monolithic molding the alloy powder by sintering, hot press or SPS method, wherein the composition formula (1) is $(Ti_{a1}Zr_{b1}Hf_{c1})_xNi_ySn_{100-x-y}$, and

a1, b1, c1, x and y satisfy the conditions of: $0<a1<1$, $0<b1<1$, $0<c1<1$, $a1+b1+c1=1$, $30 \leqq x \leqq 35$ and $30 \leqq y \leqq 35$,

and the sintered body has a dimensionless figure-of-merit ZT value of not less than 0.05 at 300° K.

Page 3 of the outstanding Office Action asserts that "the Shen patent does not use raw powders, rather it melts the raw powders together to form compounds, which compound powders are then sintered (page 166, second column)." Applicants respectfully submit that this statement is not accurate. In Shen, the raw powders are not melted, but heated at 1173K (900°C). The melting points of the metallic elements used in Shen are: Zr: 1852°C; Ni: 1455°C; and Sn: 232°C. Thus, at 1173K (900°C), only Sn is melted, Zr and Ni are not melted.

In addition, it is very difficult to perform quenching in Shen for the reasons discussed below. The pure metal powders used as starting materials in Shen are easily oxidized in the air. Shen recites that the "green bodies were put into graphite crucibles and were heated under a flowing argon atmosphere." That is, heating is performed in the argon atmosphere. In Shen, after heating in the argon atmosphere, quenching cannot be performed in the air. To perform quenching, a special facility or condition is necessary. However, Shen does not describe anything about a special facility or condition required for quenching, which proves that Shen does not indicate that quenching is performed. That is, it is not reasonable to apply quenching to the invention described in Shen. Also, Page 4 of the outstanding Office Action acknowledges that "the Shen reference fails to disclose quenching."

There are several advantages associated with Applicants' quenching step. First, when the raw materials are melted and the melted raw materials are cooled, crystals are extracted. In contrast, when the melted raw materials are cooled slowly, i.e., when quenching is not performed, the crystal grains become large, and the crystal phase is changed. Second, in the present invention, because quenching is performed, the crystal grains do not become large,

and the small crystal grains increase grain boundaries. As a result, the thermal conductivity (κ) will be small. Because the ZT value is represented by $T=\alpha 2/(\rho\kappa)$, it is clear that when the thermal conductivity (κ) becomes smaller, the ZT value becomes larger.

Applicants enclose a SEM photograph of the metallic lump obtained by quenching which demonstrates properties of Applicants' claimed thermoelectric material. The photograph shows that the crystal grains are small in comparison with Figure 8 of Shen. Since the crystal grains are small, and increased grain boundaries are obtained, the Applicants' quenching step produces a different material than the material in Shen and has advantageous properties that are superior to the material in Shen.

Page 4 of the outstanding Office Action states that "Applicant's declaration fails to show any difference with the claimed product formed by this additional quenching step." Applicants respectfully disagree. As described above, Applicants' quenching step produces a material with smaller grain size, which causes a larger ZT value than the material of Shen. As stated at page 9 of the Amendment filed on May 26, 2009, using the method of Shen, the dimensionless figure of merit ZT value of the obtained sintered body at a temperature of 300° K has a value of 0.04. In contrast, under the same conditions, Applicants' dimensionless figure of merit ZT value of the sintered body is 0.08.[1] Thus, the properties of Applicants' thermoelectric material are superior to the properties of the material in Shen.

Thus, Applicants respectfully submit that Claim 1 (and all claims depending thereon) patentably distinguishes over Shen. Further, Applicants submit that Sportouch fails to cure any of the above-noted deficiencies of Shen.

Accordingly, Applicants respectfully request that the rejections under 35 U.S.C. § 103(a) be withdrawn.

[1] See Applicants' Table 1 on page 36 of the specification; Example I-9; and page 30, lines 14-27 of the specification.

Consequently, in view of the above comments, it is respectfully submitted that the outstanding ground for rejection has been overcome and that Claims 1-4, 17 and 21-24 patentably define over the prior art. Claims 1-4, 17 and 21-24 are therefore believed to be in condition for allowance, and an early and favorable action to that effect is respectfully requested.

Respectfully submitted,

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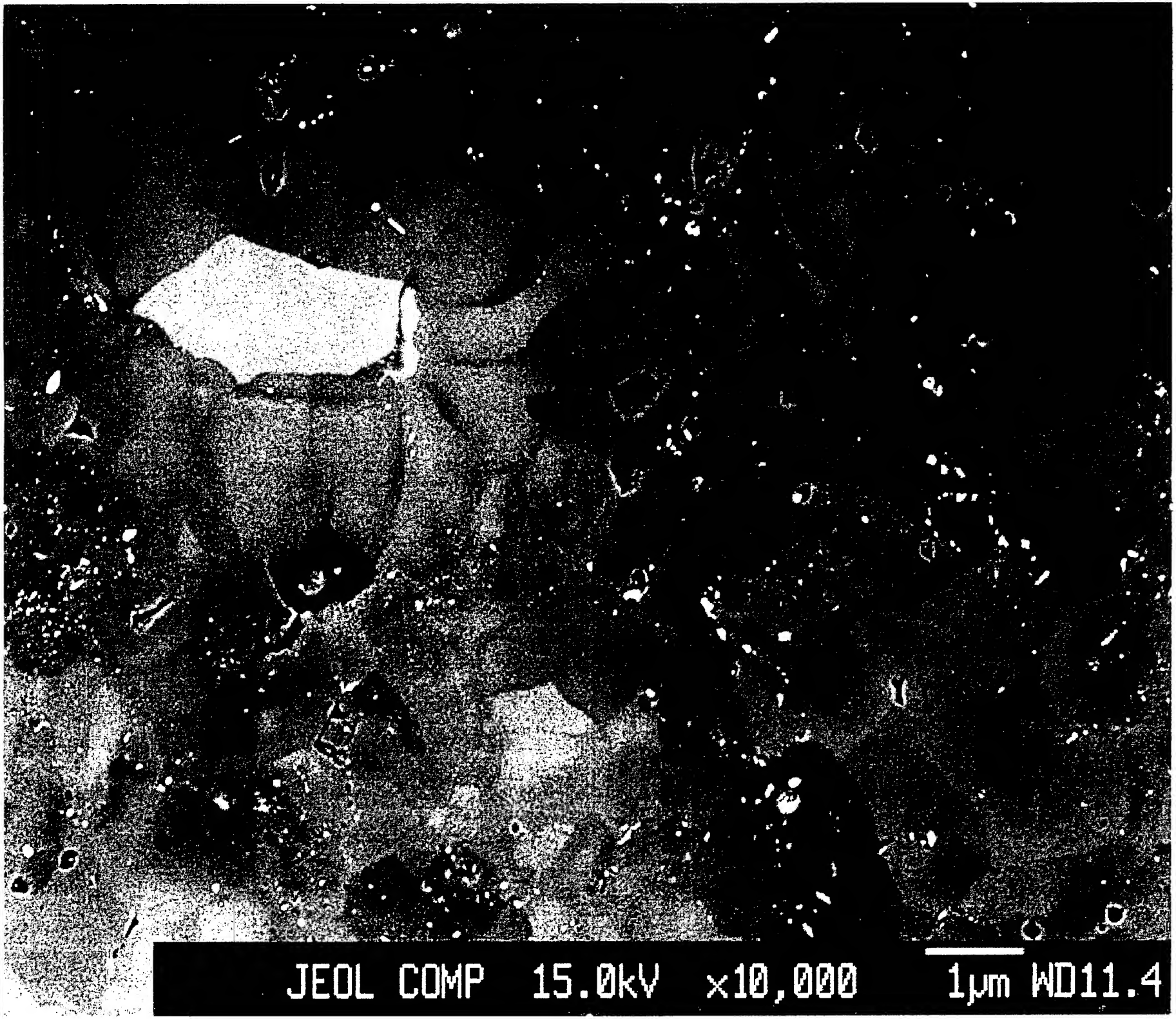
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